FINAL

MERRIMACK RIVER BASIN
BRADFORD, NEW HAMPSHIRE

TODD LAKE DAM

NH 00288

NHWRB 28.01

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1978

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NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS
DRAFT REPORT REVIEW COMMENTS
Todd Lake DAM, IDENTITY NO. NH00288
Foundations & Materials BRANCH

Comment No.	Page No.	Comments FOUNDATIONS & MATERIALS BRANCH
1	-	General: See "Boiler Plate" for cover and colonel's signature page.
2	1-3	Par. 1.2 (f): Give name ~~and~~ address of operator
3	~~2-4~~	Par. 2.4: Follow format
4	3-3	Par. 3.2: Include general evaluation of condition of dam and appurtenant structures based on results of visual inspection.
5	6-1	Par 6.1(e): Revise to read: "The dam is located in Seismic Zone No. 2 and in accordance with recommended Phase I guidelines does not warrant seismic analyses."

UNCLASSIFIED

RITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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UPPLEMENTARY NOTES

'er program reads: Phase I Inspection Report, National Dam Inspection Program; ever, the official title of the program is: National Program for Inspection of -Federal Dams; use cover date for date of report.

EY WORDS (Continue on reverse side if necessary and identify by block number)

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BSTRACT (Continue on reverse side if necessary and identify by block number)

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TODD LAKE DAM

NH 00288

MERRIMACK RIVER BASIN
BRADFORD, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No.:	NH 00339
NHWRB No.:	166.04
Name of Dam:	TODD LAKE DAM
Town:	Bradford
County and State:	Merrimack, New Hampshire
Stream:	Ring Brook
Date of Inspection:	1 June 1978, 8 July 1978 (Measurements), 12 July 1978 (Hydrology)

BRIEF ASSESSMENT

Todd Lake Dam is a concrete capped, gravity rock wall and earth fill structure with a maximum height above the downstream channel of 16.5 feet. The 57 foot long concrete cap serves as a spillway and includes two 12 foot long depressed sections which permit the installation of 12 inch high flashboards. The left abutment includes the outlet works which consist of two inlets and an outlet into 5.8 foot diameter wooden penstock; the outlet works are completely sealed, however. Initial construction was in 1858 with subsequent alterations in 1886 and 1946. No original plans are available.

The dam discharges into Ring Brook which joins the West Branch of the Warner River just below the dam. The drainage area consists of heavy, moderately sloping forest. The dam's normal impoundment of 1100 acre-feet places it in the INTERMEDIATE size category. The hazard potential classification of SIGNIFICANT results from the extensive property damage, but unlikely loss of life, expected downstream in the event of the Spillway Test Flood (STF).

The dam is in FAIR condition at the present time. Deficiencies in the areas of spillway capacity and possible structural stability require additional engineering investigations. Only a few relatively minor operation and maintenance improvements are necessary.

Based on size and hazard classification in accordance with the Corp's guidelines the Spillway Test Flood (STF) is in the range of the Probable Maximum Flood (PMF) and the 1/2 PMF. An inflow STF of 14,000 cfs (760 csm) yields a maximum outflow at the dam of 11,500 cfs (620 csm). This flow, 11,500 cfs, would result in overtopping of the dam by 6.8 feet. The maximum flow over the dam that will not result in overtopping is 1350 cfs. Thus, the spillway is considered inadequate and a major storm could result in dam failure. The resolution of this problem requires a considerable increase in the discharge capacity of the dam or the provision of suitable emergency spillway facilities. Because significant extension of the existing dam does not appear feasible and because the road bridge immediately downstream creates a flow restriction during major floods, the eventual solution may involve some modifications to both structures.

Operationally, the dam requires repair of the right downstream training wall, cleaning and sealing of some cracks and repair of some spalls in the concrete portions of the structure and clearing of the downstream channel. The installation of a gauge near the dam would assist the owners in better monitoring discharges during flood periods.

The above recommendations and remedial measures should be implemented by the owner within one to two years after receipt of the Phase I Inspection Report.

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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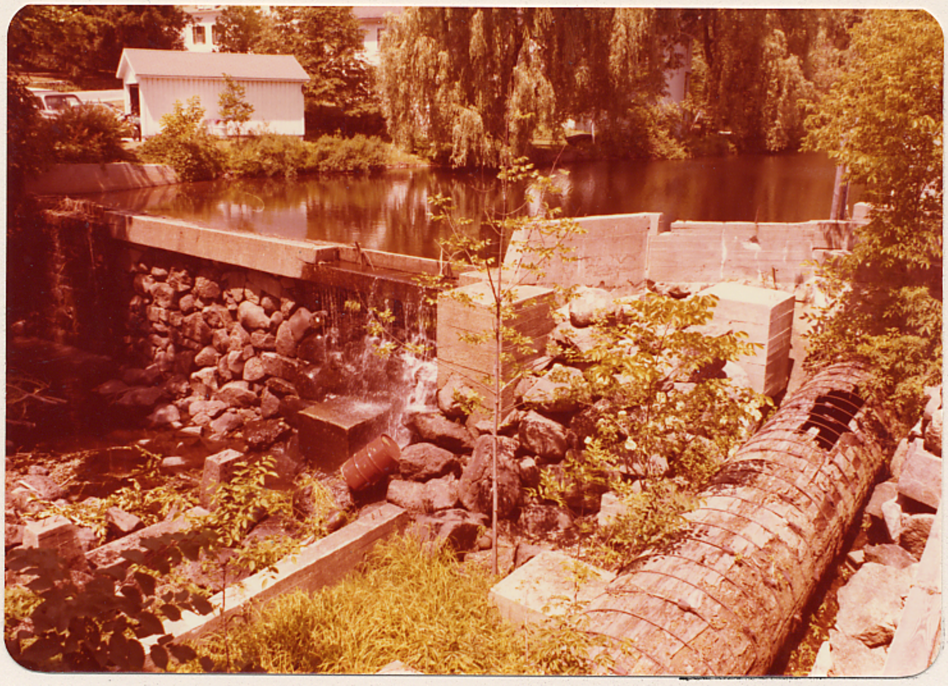
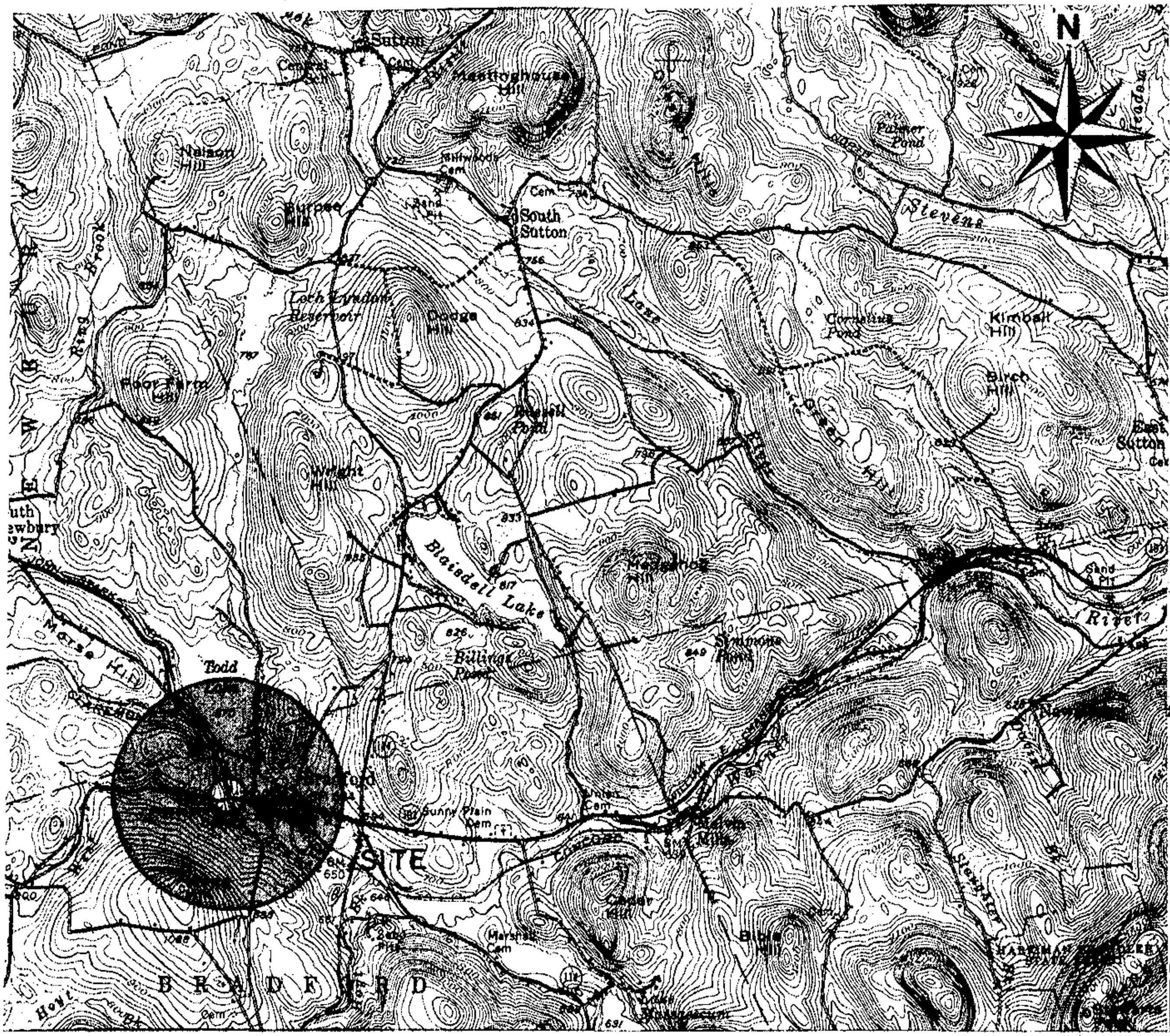


Overview from left side downstream (8 July 78)

Overview from downstream channel (8 July 78)



- SCALE -

1/2 1 2 miles

FROM: USGS MT. KEARSARGE, N.H. QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC, INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN

TODD LAKE DAM — NEW HAMPSHIRE

FILE No. 2067

SCALE AS NOTED

DATE JULY 1978

PHASE I INSPECTION REPORT

TODD LAKE DAM

SECTION 1

PROJECT INFORMATION

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates, Inc. (G.Z.D.A.), has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to G.Z.D.A. under a letter of May 3, 1978 from Colonel Ralph T. Garver, Corps of Engineers. Contract No. DACW 33-78-C-0303 has been assigned by the Corps of Engineers for this work.

(b) Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) Update, verify and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-Federal dams in the high hazard potential category based upon location of the dams and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dams.

1.2 Description of Project

(a) Location

The dam lies at the south end of Todd Lake near the intersection of old Route 103 and Morse Hill Road in the town of Bradford, NH. The portion of the USGS Mt. Kearsarge, NH quadrangle presented previously shows this locus. Figure 1 of Appendix B presents a detail of the site developed from the map and the site inspection.

(b) Description of Dam and Appurtenances

The dam consists essentially of a gravity rock wall and earth fill structure with a base width estimated at 20 feet and a maximum height of 16.5 ft. (Figure 2). A concrete spillway covers the gravity structure over its entire 57 foot length and has two 12 foot long depressed sections, one near each end, which permit the installation of 12 inch flashboards (Figure 2). The left abutment incorporates the dam's outlet works which consist of a concrete box with two inlets and one outlet. Stop-logs at one time regulated flow through the outlet which then led into a now boarded up 5.8 foot diameter wooden penstock (Figure 3). The previous owner has sealed both inlets, probably by boarding, one of which is on the right side. No special hazard is believed to attend the penstock. The outlet works originally provided flow for the operation of a saw mill complex, only part of which remains today, having been converted into a one family home. Old concrete footings for the mill buildings still exist around the dam. The wooden penstock runs into the converted mill building, as does the small amount of water which leaks through the boarded up outlet works. A concrete lined channel carries this flow under the house. A concrete arch bridge permits flow under old Route 103 approximately 100 feet downstream of the dam.

(c) Size Classification

The dam's normal impoundment of 1100 acre-feet places it in the INTERMEDIATE size category as defined in the "Recommended" Guidelines."

(d) Hazard Potential Classification

Only the converted mill building and 2 other houses lie in the downstream hazard area for a failure of this dam. While damage to these structures and to the road bridge immediately downstream of the dam would be significant there is little potential for loss of life. For these reasons, the hazard potential is considered SIGNIFICANT.

(e) Ownership

All lakeshore residents have a part ownership in the dam included in their property deeds as of 1968. The Lake Todd Association, a voluntary organization of the littoral property owners, controls the dam through its dam committee. Mr. Donald A. Garman, P.O. Box 168, Bradford, NH 03221 is the association's president. His phone number is 603-938-2314. From 1954 to 1968, Mr. Edwin Westerburg, RFD 1, Bradford, NH 03221 (603-938-2296) owned the dam.

(f) Operator

The only functional features of the dam at present are the two 12 inch flashboards. Mr. Garman, the Association president, controls their installation and removal.

(g) Purpose of Dam

While formerly used to store water for industrial use in the mill, the dam's only purpose at present is to maintain the lake level for summer recreational use.

(h) Design and Construction History

A 1934 New Hampshire Water Resource Board (NHWRB) report indicates that original construction was in 1858 with a reconstruction in 1886. Mr. Westerburg indicates that in 1946, the mill operator and dam owner Mr. Milner altered the dam to its present configuration by constructing the concrete spillway and repairing the wooden penstock. Mr. Milner drained the lake prior to construction and Mr. Westerburg reports that the rock and earth fill portion of the dam was approximately 20 feet wide at the base. No plans for the dam are available.

(i) Normal Operational Procedure

The Lake Todd Association installs the flashboards by Memorial Day at the latest and removes them by the end of September.

1.3 Pertinent Data

(a) Drainage Area

Todd Lake receives runoff from a 18.5 square mile drainage area. The majority of this area is heavily forested with moderately steep slopes toward the lake. Several small streams including Ring Brook and an unnamed stream from Loch Lyndon Reservoir discharge into Todd Lake. A large part of the development around the lake is permanent and year-round in nature

(b) Discharge at Dam Site

No formal record of historic peak floods is available for Todd Lake. There is a nearby downstream USGS gauge (01085800) on the West Branch of the Warner River, however, which provides local runoff records since 1962. For the period 1962-1978, the peak runoff is 555 cfs from a 5.75 square mile drainage area. If transposed to the Todd Lake drainage basin, this same runoff would yield an approximate peak flow of 1790 cfs.

Mr. Westerburg indicated that the maximum flood during his 50 year residency in the area occurred during the hurricane of 1938. He reports that water flowed 5 to 6 feet over the dam and that only the backwater created by the nearby roadbridge counteracted the pressures created by the tremendous flow and prevented the dam from being washed out. The 1938 flows are estimated to be in the range of 1600 to 2500 cfs.

(c) Elevation (ft. above MSL assuming Lake Todd at 670'± per 1956 USGS)

(1) Top dam: 673.5

(2) Recreation pool: 670 ± (with flashboards)

(3) Spillway crest: 669±

(4) Streambed at centerline of dam: 656±

(d) Reservoir

(1) Length of maximum pool : 6800 ft.

(2) Storage - recreational pool: 1100 acre-feet @ 670 MSL
- top of dam: 1513 acre-feet @ 673.5 MSL

(3) Reservoir surface: 168 acres @ 670 MSL

(e) Dam

(1) Type: Gravity rock wall and earth fill with concrete spillway

(2) Length: 57 ft.

(3) Height: 16.5 ft.

(4) Top Width: 10 ft. ±

(5) Side Slopes: Downstream vertical, upstream 1:1

(6) Zoning, impervious core, cutoff, grout curtain: Unknown

(f) Spillway

(1) Type: Concrete weir with 2 flashboard sections

(2) Length of weir: 33 ft. (excluding flashboard sections)

(3) Crest elevation: 669 ft. ±

(4) Gates: 2 flashboard sections, each 12 ft. long

(5) Upstream Channel: Shallow approach from pond

(6) Downstream Channel: Narrow channel with steep sides and rocky bottom

(g) Regulating Outlets

The only regulating outlets presently in use are the two flashboard sections which permit the installation and removal of 12 inch high flashboards. The base of the flashboards is at elevation 669 ft. ±.

Previous owners boarded up the dam's main outlet works described in Section 1.2(b). The inlet on the upstream side of the inlet is 4 ft. by 4 ft. It was impossible to determine the dimensions of the inlet on the right side. The top of the stoplogs at the outlet to the wooden penstock are 5.3 ft. below the top of the concrete box structure.

SECTION 2 - ENGINEERING DATA

2.1 Design

The design of the present structure is quite simple and appears adequate in all respects except ability to pass the Spillway Test Flood (STF). At the time of its design, however, engineers rarely considered floods of the magnitude now under study. Plans for neither the original nor rebuilt structure are available.

2.2 Construction

Visual inspection of the dam detected no significant construction deficiencies in the structure. Of key concern is the lack of accurate data as to the size of the gravity structure and of any information regarding the internal makeup of the dam. In general, the quality of construction is probably as good as can be expected for a structure of this type built during this period.

2.3 Operation

The facts that very little leeway in operation exists and that the residents themselves control the dam result in generally satisfactory operation.

2.4 Evaluation

(a) Availability

As mentioned above, the original plans are not available, if indeed they still exist. Previous inventory reports, sketches and correspondence concerning the dam, supplemented by the observations of the inspection team and discussions with knowledgeable residents, form the basis of the information presented herein.

(b) Adequacy

The lack of indepth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but its evaluation is based primarily on visual inspection, past performance history and engineering judgment.

(c) Validity

The direct examination and performance history form a valid basis for evaluation.

SECTION 3 - VISUAL OBSERVATIONS

3.1 Findings

(a) General

The Todd Lake Dam is in FAIR condition at the present time and requires no immediate remedial measures for continued safe operation.

(b) Dam

(1) Spillway (Photos 1 and 2)

The spillway is 57 feet long with a crest width of approximately 10 feet. The surface of the spillway consists of a concrete cap placed on the dry stone masonry dam. The cap is approximately 12 inches thick. With the exception of a horizontal crack stretching 24 ft. from one flashboard section to the other, there is no evidence of spalling or other deficiencies in the crest. The flashboards are in good condition.

The downstream face of the dam consists of dry squared stone masonry and rubble stone masonry. The dry squared stone masonry is adjacent to the right abutment and extends along the spillway face for approximately 10 feet. Some stones are dislodged out of alignment (Photo 1). Rubble stone masonry at approximately mid-length of the spillway has bulged outward and some has unraveled out of place and fallen into the channel bed. A 1939 inspection by the NHWRB noted this same deficiency. The bulge is approximately 6 feet in height and voids due to dislodged stones are 2 to 3 feet above the channel bed (Photo 2). No leaks through the stonework were evident.

(2) Abutments (Photo 4)

The abutments consist of dry stone masonry capped with concrete. The dry squared stone masonry forming the right abutment is no longer plumb with evidence of numerous displaced stone. There is a void approximately 6 inches by 2 feet long between the dry stone and the concrete cap. The concrete cap on the right abutment contains medium random cracks and efflourescence. The left abutment joins a concrete pier located at the edge of the spillway. This pier rests in the channel bed. Dry stone masonry supports the balance of the abutment. This abutment has spalled with evidence of medium random cracks and efflourescence (Photo 4). Heavy boulders sloping from the channel bed to the bottom of the concrete cap preclude visual inspection of this abutment. The concrete cap on the left abutment is in fair condition. No leaks through or around the abutments were evident.

(c) Appurtenant Structures (Photos 3 and 6)

The left abutment, as shown in Photo 3, is of concrete, and overtopping flows would deflect into an open area to the east of the converted mill. A concrete outlet is integral to the left abutment and internal dimensions are approximately 7 feet wide and 11 feet long. The structure is approximately 9 feet deep. The concrete contains medium random cracking and efflourescence. The water level within the structure was approximately 1 foot below lake level on June 1, 1978. The structure has two inlets and one outlet. One inlet is on the upstream face of the structure and the other is in the right wall. The upstream inlet consists of a 4 foot by 4 foot opening. It was not possible to measure the dimensions of the right inlet. Both inlets are sealed with wood. The outlet, which has stop-logs set in place, is on the downstream end of the structure. The top of the stop-logs are 5.3 feet below the top of the structure. Due to their submerged condition, visual inspection of the stop-logs is not possible, however a representative of the owners indicated that they are 4 inches in nominal thickness. There is leakage at the inlet end of the penstock, probably due to faulty seating of the stop-logs. The wood stave penstock is in poor condition and beyond salvage. At least 50 percent of the staves are completely deteriorated (Photo 6).

(d) Reservoir

An inspection of the reservoir shore revealed no evidence of movement or other instability. No sedimentation was evident behind the spillway. Examination of the surrounding area revealed no work in progress or recently completed which might increase the flow of sediment into the lake. Additionally, there were no changes to the surrounding watershed which might adversely affect the run-off characteristics of the basin.

The relocation of Route 103 across the old railroad embankment has no effect on the lake level. The bridge constructed near the east end of the embankment is sufficiently large to allow the two bodies of water to act as one.

There is considerable development, both seasonal and year-round, on the Todd Lake shoreline. Many houses are less than 10 feet above normal lake level. If major flooding occurred, many structures would likely suffer significant damage.

(e) Downstream Channel (Photo 5)

There are no downstream conditions which adversely affect the operation of the dam or which pose a hazard to the safety of the structure.

The existence of the road bridge just downstream of the dam would create significant backwaters at the dam in the event of the STF, a situation more beneficial than harmful in terms of the dam's structural stability. The bridge is a concrete arch with a width of approximately 16 feet and a maximum height of approximately 16.5 feet. The narrow, steep channel for some distance downstream virtually assures high water levels around the channel, but the lack of any significant downstream development indicates that property damage is the greatest danger.

The collapsed downstream training wall on the right side (Photo 6) presents no immediate hazard to the dam or to downstream areas, but does require routine repair to channel discharge properly and to prevent undermining of the nearby road.

3.2 Evaluation

Because the dam is of simple design and because most of its major components are accessible for examination, the visual inspection permitted an overall satisfactory evaluation of those items which affect the safety of the structure, and the overall condition of the dam and appurtenant works is considered as FAIR.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

Each year, the Lake Todd Association installs the two 12-inch flashboards before Memorial Day and removes them in late September. The dam presently has no other operation features and the association has had no reason or received any complaints which would cause them to alter this procedure.

4.2 Maintenance of Dam

The present owners have performed no significant maintenance on the dam since assuming control. The extensive alteration performed in 1946 appears to be the last major maintenance effort on the structure.

4.3 Maintenance of Operating Facilities

The dam's flashboards require only minimal attention.

4.4 Description of Any Warning System in Effect

No formal warning system exists for the dam. For this particular structure the lack of any real operational capacity at present indicates that a warning system is only effective for notification of impending failure. In all probability, the interest of local residents would adequately serve this purpose.

4.5 Evaluation

The established operational procedures are adequate for Todd Lake Dam given its limited operational capacity.

SECTION 5 - HYDROLOGIC/HYDRAULIC

5.1 Evaluation of Features

(a) Design Data

The data sources available for Todd Lake Dam include the "Inventory of Dams and Water Power Developments" by the New Hampshire Water Resource Board, dated October 10, 1934, and "Data on Dams in New Hampshire" by the New Hampshire Water Control Commission, dated October 26, 1938, and updated July 15, 1942. These sources deal primarily with the characteristics of the dam and its spillway.

A June 26, 1944 application for repair of the dam is also available, as is a series of letters written in 1967 and 1968 dealing with high flows in the West Branch of the Warner River downstream of Lake Todd. More recent data include "Dam Safety Inspection Report Forms" and "Site Evaluation Data" from the New Hampshire Water Resources Board, dated May 17, 1971, August 19, 1975, and April 28, 1976. There is also a series of letters between the New Hampshire Water Resources Board and the Lake Todd Association (owner/operator of the lake) regarding the need for a controlled outlet at the dam. The New Hampshire Water Resources Board wrote on January 27, 1976 requesting "corrective action ... to increase flow capacity during floods." The data also include a May 20, 1977 letter from the Corps of Engineers to the Lake Todd Association explaining that federal funding is not available for this type of corrective action.

(b) Experience Data

No formal record of historic peak floods is available for the Todd Lake Dam. There is a nearby USGS gauge (01085800) on the West Branch of the Warner River that provides runoff records since 1962. For the period of record, the peak runoff is 555 cfs from a drainage area of 5.75 square miles. The same runoff rate, if transposed to the Todd Lake drainage basin, would yield an approximate peak runoff of 1,790 cfs. The recollections of one of the previous owners, discussed in Section 1.3 (b) provide additional insight into the discharges possible in this area, in this case on the order of 1600-2500 cfs after the 1938 hurricane.

(c) Overtopping Potential

This Phase I investigation focuses on the adequacy of the dam in terms of its overtopping potential and its ability to allow an appropriately large storm to pass safely. This approach requires investigations to determine how the recommended Spillway Test Flood (STF) compares with the dam discharge and storage capacities. Since none of the original hydraulic and hydrologic design records are available for use in this study, the analysis requires some of the basic calculations reported herein.

The "Recommended Guidelines" specify Spillway Test Flood criteria based on the size and hazard potential classifications of the dam. As shown in Table 3 of that publication, the appropriate STF for a dam classified as INTERMEDIATE in size with SIGNIFICANT hazard potential, is between 0.5 to 1 times the Probable Maximum Flood (PMF).

The chart of "Maximum Probable Flood Peak Flow Rates" obtained from the Corps of Engineers, New England Division permits an estimate of the PMF. The calculations use "rolling" topography with a drainage area of 18.5 square miles. However, the existence of the Loch Lyndon Reservoir and extensive swamp lands along Ring Brook tend to partially lower the appropriate estimate for the peak runoff rate. This results in a maximum probable runoff rate into the lake of about 1,250 cfs/square mile or 23,125 cfs, one-half of which is 11,565 cfs.

The "Recommended Guidelines" suggest that where a range of possible STF's is indicated, the analysis should consider the magnitude most closely relating to the involved risk. On this basis, since the risk for Todd Lake is most likely at the lower end of the SIGNIFICANT category, an STF closer to one-half the PMF is appropriate. In this case, a value of 14,000 cfs is reasonable for an uncorrected STF inflow. Application of the procedure suggested by the Corps of Engineers (New England Division) for "Estimating the Effect of Surcharge Storage on Maximum Probably Discharges" results in a final STF outflow of about 11,500 cfs.

The Storage-Stage curve used to attenuate the STF results from assuming a lake area of 168 acres and allowing for a simple linear relation for storage versus elevation above spillway crest. Appendix D presents this curve.

The discharge capacity of the Todd Lake Dam depends on the outlet characteristics and on the level of the water surface in the lake. Under most flow conditions the spillways and the top of the dam control discharge from the lake. If the lake level overtops the dam abutments, then the discharge capacity depends on the characteristics of the dam crest and the side walls along the abutments.

The analysis of the dam's discharge during the STF presented in Appendix D uses the following assumptions.

(1) Blockage of the penstock gate is complete.

(2) The force created by the flow over the dam washes out the flashboards.

(3) Once overtopped, the walls on either side of the dam act as sharp crested weirs while the level lot on the east side acts as a broad crested weir. The slopes beyond the wall on the west side and beyond the parking area on the east side assume the characteristics of broad-crested weirs on 1:1 side slopes.

The Discharge-Storage curve in Appendix D illustrates the total outflow from the lake for any given stage. As the calculations indicate, the STF of 11,500 cfs will overtop the dam by 8.5 feet.

5.2 Hydrologic and Hydraulic Evaluation

Given the limited flow capacity of the spillway at Todd Lake Dam, the recommended STF will significantly overtop the dam and its abutments. Furthermore, since the maximum capacity before overtopping is only 1,350 cfs, overtopping will also occur for many storms of smaller magnitude than the recommended Spillway Test Flood.

Route 103 as reconstructed cuts the lake in half where it follows along the former railroad embankment. If the opening through the embankment was small enough to severely restrict flow, the embankment might serve to partially dam the river and attentuate the peak flow entering the lake below the embankment. Examination of the highway bridge however, indicates that the area beneath the bridge equals approximately 750 square feet and that there is relatively little freeboard between the low chord of the bridge and top of the embankment. This combination of the large flow area and probability of overtopping under surcharge suggests that the highway does not clearly define two lakes and thus would not limit the peak flow at the dam for very large floods. The highway opening is thus hydraulically insignificant.

In the event of a flood of the Spillway Test Flood magnitude, three structures immediately downstream of the dam would suffer severe damage. They are the old mill building, since converted to a residence, and the two houses which overhang the stream immediately downstream of the first road bridge. A larger number of lakeside homes upstream of the dam would suffer severe flooding by the stage in the lake that would accompany an STF magnitude flood.

It is unlikely that the Todd Lake Dam would rise to the overtopping level without sufficient time to evacuate the residents of the downstream structures immediately threatened. There is very limited development downstream for a considerable distance and, thus, the need to improve the spillway capacity is more a function of preventing flooding upstream along the shores of the lake than downstream due to dam failure. However, the purposes of the dam safety review do not include the prevention of upstream flooding on the lake shore.

5.3 Downstream Dam Failure Hazard Estimates

Use of the procedures set forth in "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs," Corps of Engineers, New England Division, April 1978, permits estimation of the flood hazards in downstream areas resulting from a failure of the dam. This procedure includes the attenuation of dam failure hydrographs in computing flows and flooding depths for downstream areas. The calculations take into account the hydraulic and storage characteristics of channel reaches downstream of the dam and assume that failure occurs when the lake level rises 4.5 feet over the spillway, or with the initial flow of water over the left abutment.

The evaluation divides the channel downstream of Todd Lake Dam into three reaches. The first reach extends from the dam to the first bridge immediately downstream. The second reach runs along Ring Brook and the Warner River to the covered bridge. The third reach is from this bridge to the Highway 114 bridge across the Warner River.

Cross-sections taken from the USGS quadrangle provided the basis for estimating depths of flooding for each downstream reach. In each case, the flooding would overflow the natural stream banks but would remain in the low areas along the banks. With the exception of those mentioned previously, there are no known structures in the area flooded for the three reaches considered.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

With the exception of the bulge near the center of the downstream face, the field investigation revealed no significant displacements and/or distress which warrant the preparation of structural stability calculations based on assumed sectional properties and engineering factors. The potential hazard from the bulge is not clear, particularly in light of its existence since at least 1939. Section 7 includes a recommendation with respect to this feature.

(b) Design and Construction Data

As mentioned previously, no plans or calculations of value to a stability assessment are available for this dam.

(c) Operating Records

There are no formal operating records in existence for this dam. However, contact with long-time residents revealed no visual evidence of any instability during past floods. The survival of the dam during the 5 to 6 foot overtopping in 1938 provides some insight into its stability, but this incident may, however, have caused the present bulge, first noted in 1939.

(d) Post Construction Changes

The alteration accomplished in 1946 did not affect the stability of the structure. The results of the field inspection and a check of the available records produced no evidence of other changes to the dam which might influence its stability.

(e) Seismic Stability

The dam is located in Seismic Zone No. 2 and in accordance with recommended Phase I guidelines does not warrant seismic analyses.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The Todd Lake Dam is in FAIR condition at the present time.

(b) Adequacy of Information

The known characteristics of the dam, its drainage area and its downstream areas are such that the information now available permits a satisfactory evaluation.

(c) Urgency

The engineering studies and improvements described herein should be implemented by the owner within 1 to 2 years after receipt of the Phase I Inspection Report.

(d) Need for Additional Investigation

Further investigations to determine the influence of the bulge on the stability of the dam and the affects of the old Rte. 103 bridge immediately downstream are necessary.

7.2 Recommendations

(a) As the dam will not pass the test flood without severe overtopping, further structural and hydrologic studies are necessary by competent consulting engineers to determine the effect of overtopping and what measures may be necessary to improve discharge capabilities.

(b) The cause and possible effects of the bulge in the downstream face of the dam are not known. An engineering study of this situation is necessary to insure the long-term safety and stability of the dam.

(c) Possible adverse effects of the apparently constricted opening of the Old Rte. 103 bridge downstream should be inspected.

7.3 Remedial Measures

(a) Alternatives

With the exception of the two areas discussed in the preceeding paragraph, the dam suffers from only minor deficiencies. The long-term safety of the dam requires institution of a regular maintanance program to correct such deficiencies prior to their leading to major problems. Alternatively, at the sacrifice of a useful recreational resource, the dam could be breached.

(b) O & M Procedures

Implementation of the following measures will assist the owners in assuring the long-term safety of the dam:

(1) Clear all debris, particularly logs and branches, from the downstream channel.

(2) Reconstruct the right downstream training wall.

(3) Clean out and seal all cracks in the concrete portions of the dam, particularly the spillway, and repair all spalled areas.

(4) Install a staff gage upstream of the dam which will provide visual readings during flood periods. These observations will provide information on future flood discharges.

(5) Continual surveillance of the dam should be provided by the owner during periods of unusually heavy precipitation. The owner should also establish a formal system with local officials for warning downstream residents in case of emergency.

APPENDIX A

VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Dates:	1 June 1978 8 July 1978 - 11:00 a.m. (Measurements) 12 July 1978 - 11:00 a.m. (Hydrology)
	NH 00288 TODD LAKE DAM Bradford, New Hampshire Ring Brook NHWRB 28.01
Weather:	Sunny, warm all days

INSPECTION TEAM

James H. Reynolds	Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZDA)	Team Captain
William S. Zoino	GZDA	Soils
Nicholas A. Campagna	GZDA	Soils
Robert Minutoli	GZDA	Soils
Andrew Christo	Andrew Christo Engineers (ACE)	Structural & Mechanical
Paul Razgha	ACE	Structural & Mechanical
Guillermo J. Vicens	Resource Analysis, Inc. (RAI)	Hydrology
David H. Marks	RAI	Hydrology
Richard L. Laramie	RAI	Hydrology
Duncan W. Wood	RAI	Hydrology

Mr. Donald A. Garman, president of the Lake Todd Association was present during the 1 June 1978 inspection.

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
ROCK & EARTH EMBANKMENT		
Movement or Settlement of Crest	nac	None noted
Vertical Alignment	nac	No movement noted
Horizontal Alignment	nac	No movement noted
Condition at Abutment and at Concrete Structures	ac	Right abutment: some movement of squared stone and medium random cracks and efflouresence on cap Left abutment: some spalling and random cracks of and efflourescence on concrete
Unusual Movement at or near Toes		
Unusual Downstream Seepage	nac	None noted
Foundation Drainage Features	a	None visible
Toe Drains	ac	None visible
OUTLET WORKS		
(a) Approach Channel		
Slope Conditions	nac	Shallow approach from pond
Bottom Conditions	ac	Not visible
Log Boom		None
Debris		None
Trees overhaning channel	ac	None

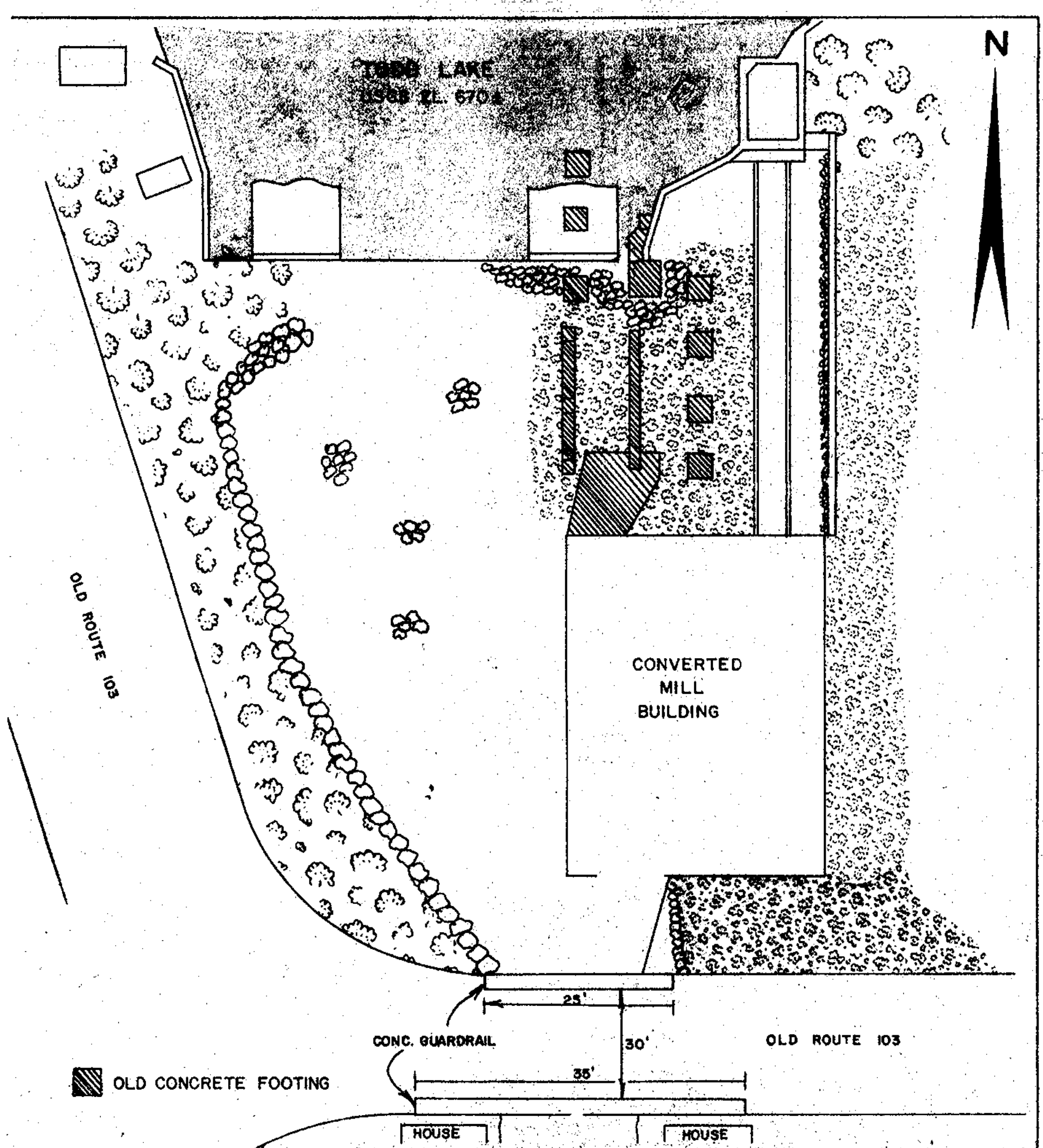
CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	BY	CONDITION & REMARKS
(b) Outlet Structure	AC	
General Condition of Concrete		Good; inlets and outlets sealed but minor leakage through wood seals
Rust or Staining		None noted
Spalling		None noted
Erosion or Cavitation		None noted
Visible Reinforcing		None noted
Seepage or Efflourescence		Some efflourescence on box structure
Cracking		Some medium random cracks
Wooden Penstock		Very poor, about 50 percent of wood deteriorated
Stop-logs		Not visible (submerged)
(c) Spillway Weir		
General Condition of Concrete		Good
Rust or Staining		None
Spalling		Minor
Visible Reinforcing		None
Seepage or Efflourescence		None
Cracking		24-foot long horizontal crack on downstream face of cap between flashboard sections
Condition of flashboards	AC	Good

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
(d) Outlet Channel		
General Condition		Some brush, logs and other debris
Loose Rock Overhanging Channel		Right rock training wall collapsed into channel
Trees Overhanging Channel	MCC	None
Floor of Channel		Loose rock
Other Obstructions		Road bridge 100 ft. downstream
(e) Existence of gages		None
RESERVOIR		
Shoreline		Stable to 1500 feet upstream on either side
Sedimentation		None noted
Upstream hazards in the event of backflooding		50-60 beach front homes subject to inundation if lake rises 5 feet
Changes in the nature of watershed (agriculture, logging, construction, etc.)		None noted, watershed primarily forest
DOWNSTREAM CHANNEL		
Restraints on dam operation		Road bridge with arch opening 100 ft. downstream of dam might cause significant backflooding. Downstream channel very narrow

CHECK LISTS FOR VISUAL INSPECTION		
AREA EVALUATED	**BY**	**CONDITION & REMARKS**
OPERATION AND MAINTENANCE FEATURES		
Reservoir regulation plan		
Normal procedures		Flashboards inserted by Memorial Day and removed by end of September
Emergency procedures		Removal of 2-12 inch flash-boards provides little emer-gency relief. No warning system in effect, but probably not required.

APPENDIX B



GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

FIG. I

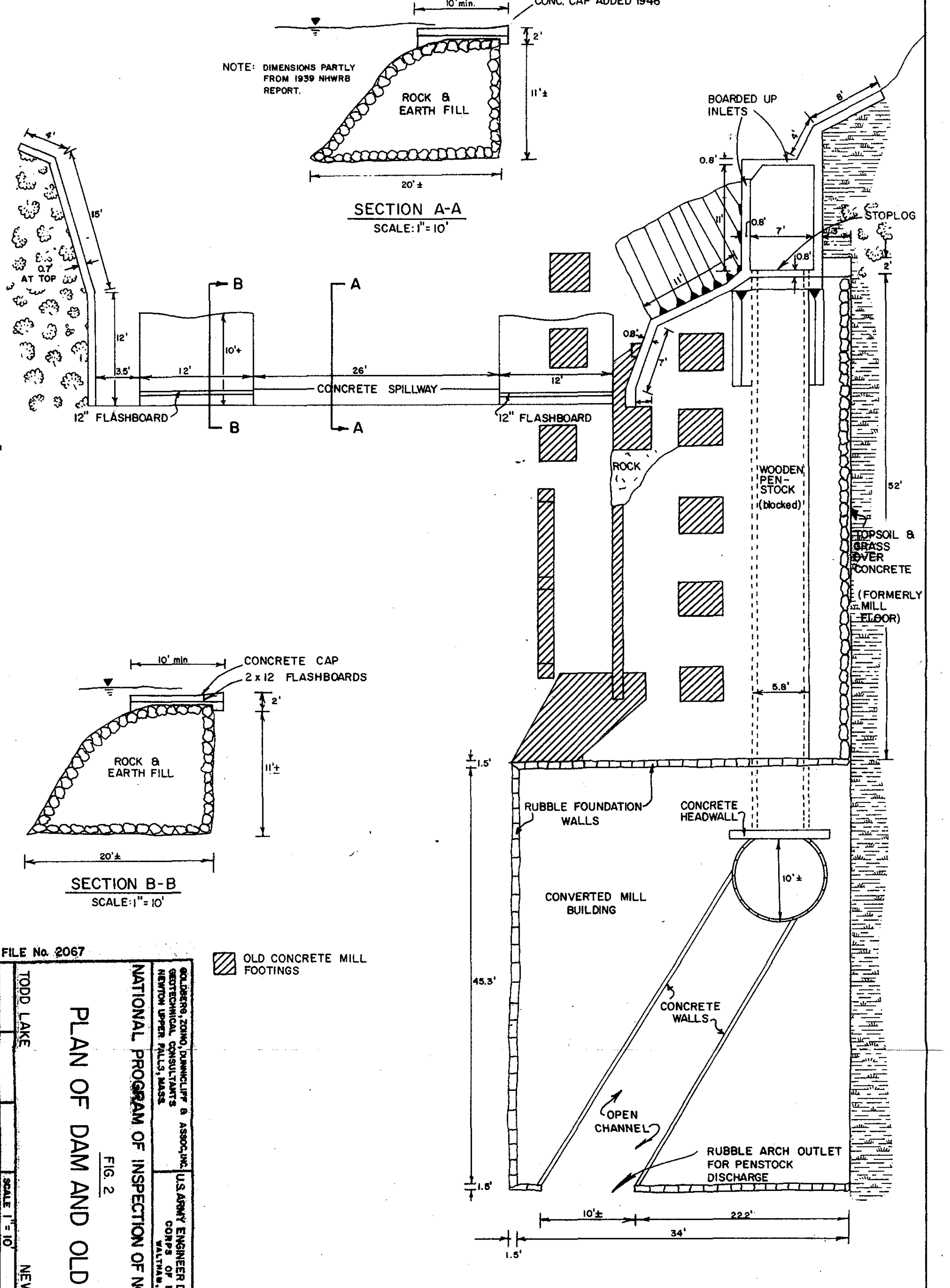
SITE PLAN

TODD LAKE — NEW HAMPSHIRE

FILE No. 2067

SCALE 1" ≈ 20'

DATE JULY 1978



FILE No. 2067

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

FIG. 2

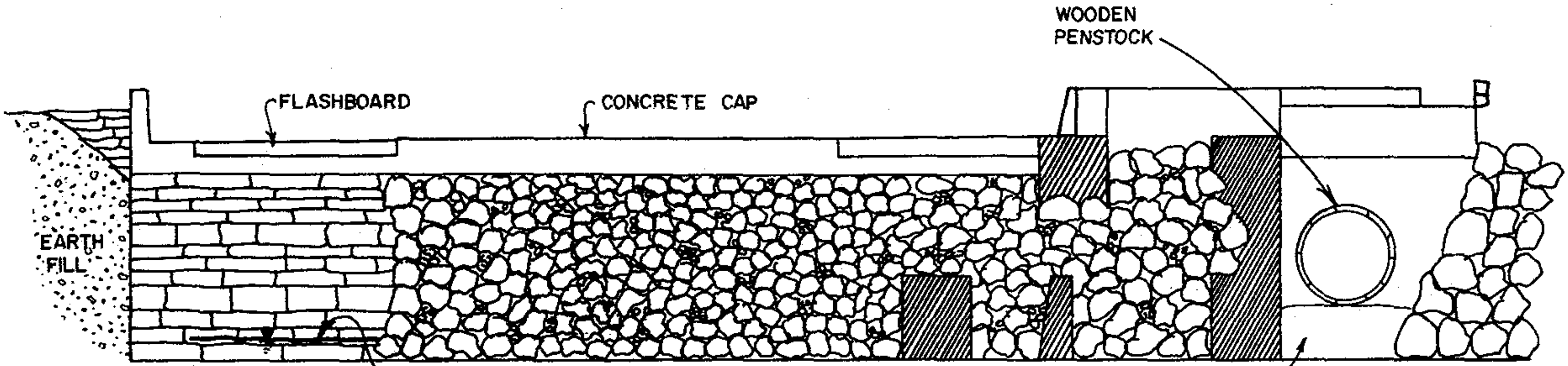
PLAN OF DAM AND OLD MILL

TODD LAKE

NEW HAMPSHIRE

SCALE 1" = 10'

DATE JULY 1978



ELEVATION

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC, INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

FIG. 3

ELEVATION OF DAM

TODD LAKE NEW HAMPSHIRE

SCALE 1" = 10'

DATE JULY 1978

FILE No. 2067

OLD CONCRETE MILL FOOTING

The NHWRB maintains the majority of information regarding the Todd Lake Dam. Included in these records are:

(a) Letter dated 8 June 1976 from Donald A. Gorman to the NHWRB concerning the findings of the Board's April 1976 inspection.

(b) Site evaluation report by the NHWRB dated 28 April 1976.

(c) Report of 28 April 1976 inspection by the NHWRB.

(d) Letter dated 27 January 1976 from the NHWRB to the Lake Todd concerning repairs recommended after the May 1971 inspection by the NHWRB.

(e) Site evaluation report by the NHWRB dated 19 August 1975.

(f) Memorandum dated 13 August 1975 concerning flooding in the West Branch of the Warner River and prepared by the NHWRB.

(g) Report of 17 May 1971 inspection by the NHWRB.

(h) A 1951 analysis of the discharges from Todd Lake prepared by the NHWRB.

(i) A 1944 request to the New Hampshire Water Control Commision (NHWCC) by Carl F. Milner to repair the dam at Todd Lake.

(j) A NHWCC data card dated 5 September 1939.

(k) A sketch of the dam dated 10 July 1939 by the NHWRB.

(l) A 1939 NHWCC report entitled "Data on Reservoirs and Dams in New Hampshire."

(m) A 1938 NHWCC report entitled "Data on Power Development in New Hampshire."

(n) A 1938 NHWCC report entitled "Data on Dams in New Hampshire."

(o) A 1934 NHWRB report entitled "Inventory of Dams and Water Power Developments."

(p) An undated Public Service Commission of New Hampshire "Dam Record."

The Board has offices in the State Capital and can be reached at (603) 271-3406 or through (603) 271-1110.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

RECEIVED
G.M. M.S.
NEW HAMPSHIRE
WATER RESOURCES BOARD

5

REPLY TO
ATTENTION OF:

NEDPL-P

20 May 1977

Mr. Donald A. Garman, President
Lake Todd Association
Box 168
Bradford, N.H. 03221

Dear Mr. Garman:

This will inform you of our findings resulting from reconnaissance scope investigations of the Lake Todd Dam in Bradford, New Hampshire. In response to Congressman James C. Cleveland's letter of 4 January 1977, on your behalf, members of my staff met with you on 7 April 1977 to discuss and inspect the subject problem area. The purpose of the meeting was to determine if Federal funding could be utilized for installation of a sluice gate at the Lake Todd Dam.

Lake Todd is an artificially created lake, located in the towns of Bradford and Newbury, New Hampshire, about 25 miles west of Concord. The damming of a water course, which was part of the Warner River system within the Merrimack watershed, created Lake Todd more than 100 years ago. The water level in Lake Todd is maintained by underground springs and the runoff collected by small streams in the surrounding hills. Route 103, a former railroad crossing, divides the lake into two sections. Preservation and development around the immediate pond area is provided through the efforts of the Lake Todd Association. Years ago, a mill was located on the left abutment of the dam and, by means of a penstock, obtained water to operate the mill machinery. The mill has been closed down for a long time and was just recently bought and is being converted into a residence by the new owner. The old wooden penstock is in an advanced state of decay and its intake has been boarded up by the Lake Todd Association.

Presently, the primary use of the dam is to maintain a sufficiently high water level in Lake Todd for recreational use during the summer months. This regulation is achieved by the insertion of a flashboard along the crest of the dam near each abutment at the beginning of the summer.

NEDPL-P 20 May 1977
Mr. Donald A. Garman, President

In August 1975, the New Hampshire Water Resources Board, in accordance with state statutes, made an inspection of the Lake Todd Dam and found it deficient in several areas. The principal problems involved the penstock and its intake structure which the association had boarded up. The boarded up intake structure was leaking noticeably and could not be operated to regulate flow through the dam. The association was informed, in January 1976, that corrective action should be taken to remedy the problem so as to increase flow capacity during times of flooding in order to insure the stability of the dam.

In conversation with the New Hampshire Water Resources Board, we were informed that installation of a moveable sluice gate was not the only solution to correct the problem and thus bring the dam in line with state statutes. The use of an operational stoplog gate in place of the boarded up penstock intake, or the lowering of the crest of the dam in conjunction with the installation of a new flashboard structure on top of the dam and permanent closure of the penstock intake, would also be acceptable to the state.

For the most part, there is no flooding problem upstream of the Lake Todd Dam. Some limited flooding does occur to low-lying land adjacent to the shores of the lake, but it is of short duration and causes very minor economic damage. Under authority contained in Section 205 of the 1948 Flood Control Act, as amended, the Corps is able to participate in the construction of flood control projects if flood prevention benefits exceed project costs. Inasmuch as only minor economic losses are incurred during times of flooding, Federal participation to install a sluice gate at the Lake Todd Dam is not feasible or economically justified.

A copy of this letter is being forwarded to the New Hampshire Water Resources Board for their information.

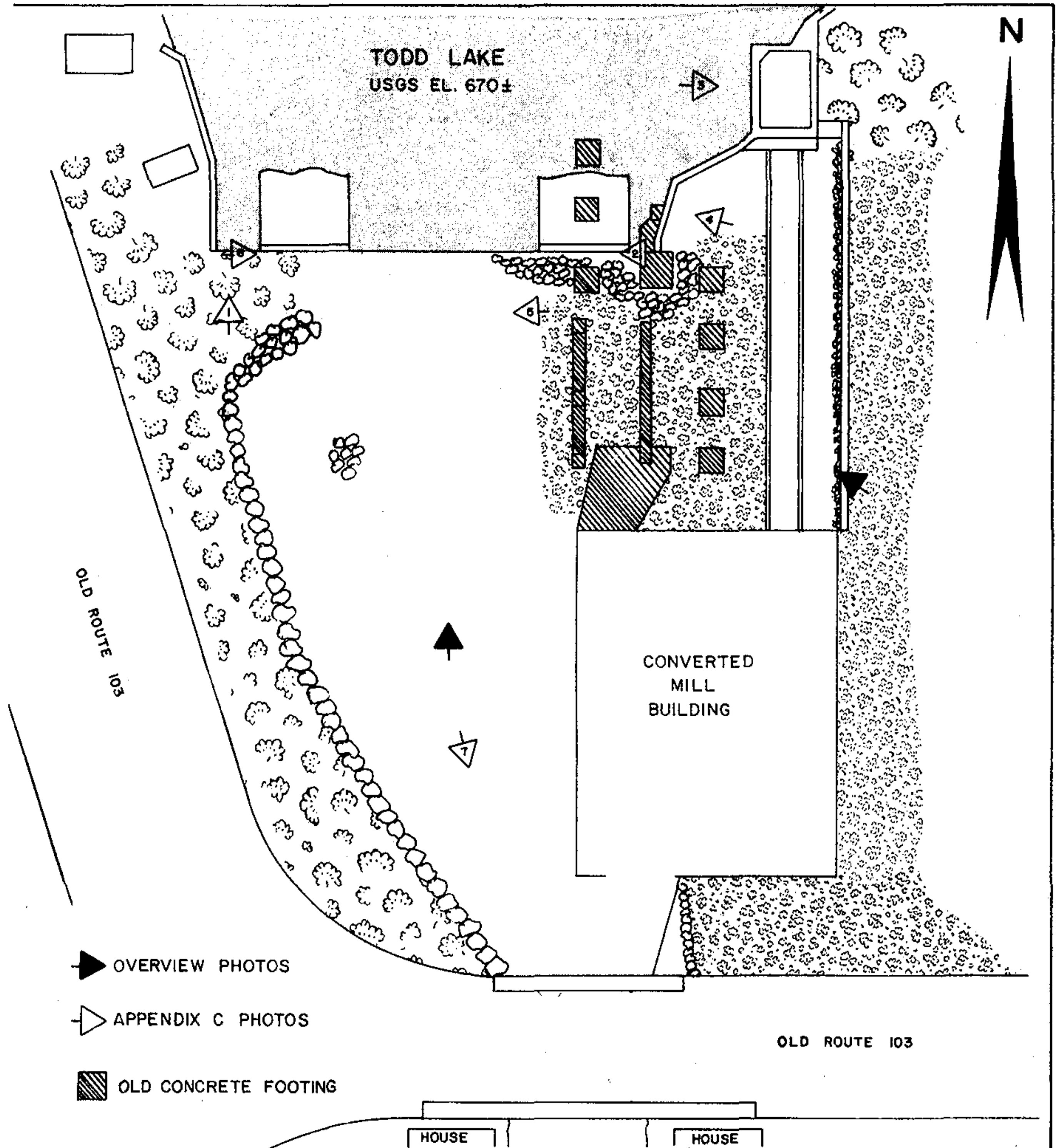
Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

CF:
✓Mr. George McGee, Sr., Chairman
N.H. Water Resources Board
37 Pleasant Street
Concord, N.H. 03301

APPENDIX C

SELECTED PHOTOGRAPHS



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WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION AND ORIENTATION OF PHOTOS

TODD LAKE — NEW HAMPSHIRE

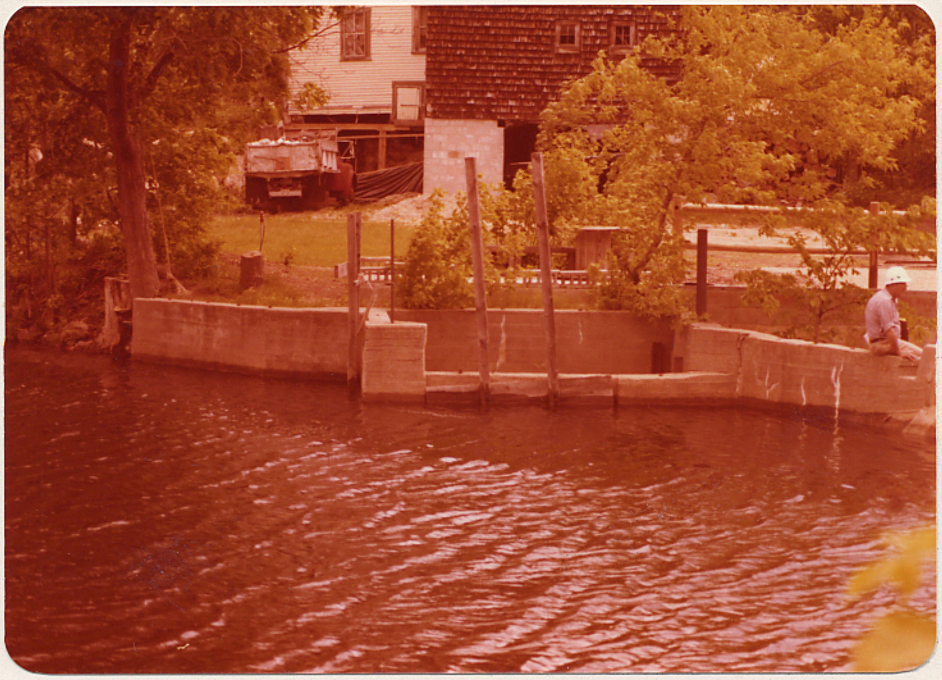
FILE No. 2067

SCALE 1" ≈ 20'

DATE JULY 1978

1. View of right abutment and right side of spillway from downstream (8 July 78)

2. View of displaced rock and bulge at toe of dam beneath center of spillway from right abutment (8 July 78)



3. View of outlet structure from right abutment (1 June 78)

4. Detail of spalling and efflourescence on concrete forming left abutment (1 June 78)

5. View of collapsed right training wall from left abutment (8 July 78)

6. View of penstock from right abutment (1 June 78)

7. View looking downstream of road bridge just below dam

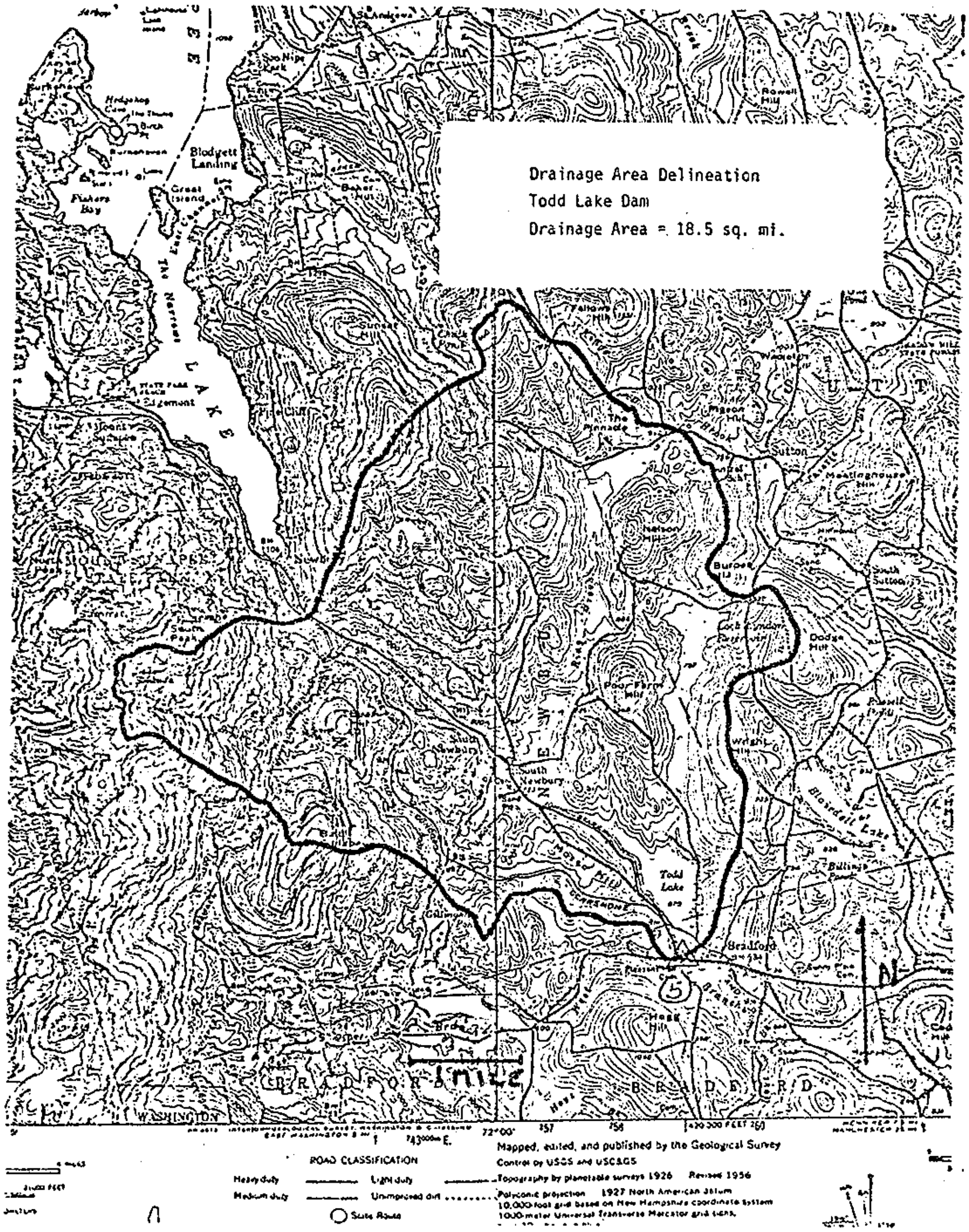
APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

FOR

TODD LAKE DAM

NH 00288


Drainage Area Delineation
Todd Lake Dam
Drainage Area = 18.5 sq. mi.
Blodgett Landing
The Pinnacle
Sutton
South Newbury
Todd Lake
Bradford
Mapped, edited, and published by the Geological Survey
Control by USGS and USC&GS
ROAD CLASSIFICATION

DAMS 148 | TODD LAKE #5 | 7-13-79 DWN

SIZE CLASSIFICATION : INTERMEDIATE

HAZARD CLASSIFICATION : SIGNIFICANT

BASED ON EXISTENCE OF TWO RESIDENTIAL STRUCTURES PLUS CONVERTED MILL BUILDING IMMEDIATELY DOWNSTREAM OF DAM, PLUS SECONDARY ROAD CROSSING.

SPILLWAY DESIGN FLOOD : = $\frac{1}{2}$PMF → PMF

DRAINAGE AREA 18.5 mi^2 (RAI)

OLD DATA (1939) has 15.5 mi^2

FROM COE CURVE –

GIVEN LOCH LYNDON RESERVOIR AND SWAMP AREAS ALONG RING BROOK WE SELECTED A RUNOFF VALUE SOMEWHAT LESS THAN "ROLLING".

USE 1250 CSM, PMF = 18.5(1250) = 23125

$\frac{1}{2}$PMF = 11563 ; FOR SDF USE 14000 cfs SINCE TODD LAKE IS ON LOWER END OF SIGNIFICANT HAZARD CLASS.

THE RUNOFF INFLOW HYDROGRAPH WOULD BE ATTENUATED BY STORAGE, USING THE COE METHOD

$$Q_{P2} = Q_{P1} \times \left(1 - \frac{STOR_1}{19}\right) = 14000 \times \left(1 - \frac{2.11}{19}\right)$$

$$Q_{P1} \Rightarrow H_1 = 12.4 \Rightarrow STOR_1 = 2.11$$

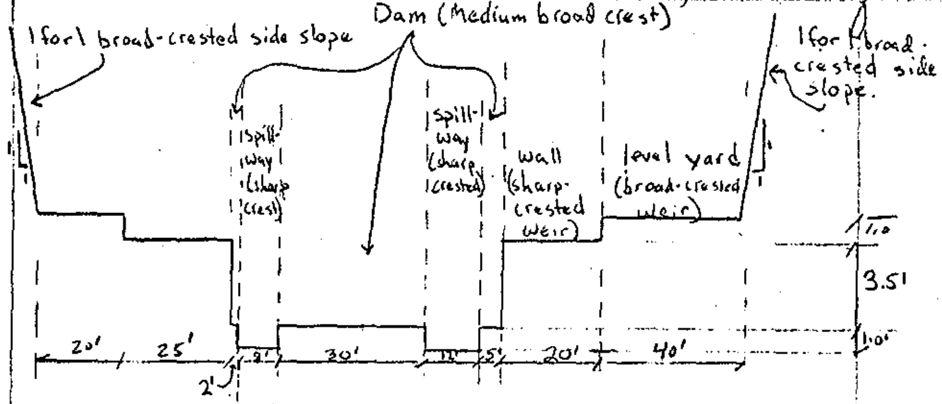
$$Q_{P2} = 12445 \Rightarrow H_2 = 11.8 \Rightarrow STOR_1 = 2.01$$

$$\overline{STOR} = (2.11 + 2.01)/2 = 2.06$$

$$Q_{P3} = 14000\left(1 - \frac{2.06}{19}\right) = 12482 \approx 12500 \text{ cfs.}$$

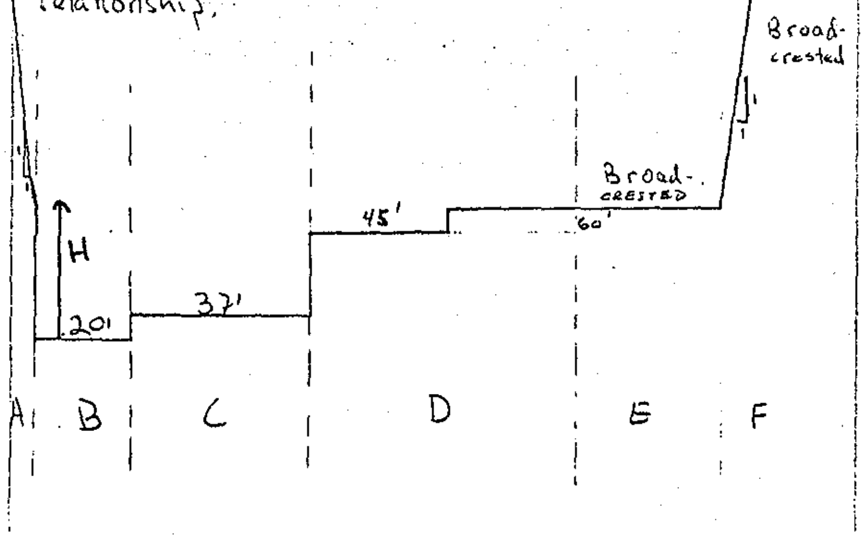
$$H_3 \approx 11.8'$$

Dams 148 | Todd Lake #5 | 7-6-78, TCG



Elevation of Todd Lake Dam.

Since flow depends only on length and weir type, we could replace that dam with this "equivalent structure," and get the same stage-Discharge relationship.



1. $Q_A = C_A L_A H_A^{3/2}$

$C_A = 2.8$ for broad-crested weir over ground

$L_A = H - 5.5$

$H_A = .5(H - 5.5)$

$\underline{Q_A = 2.8 \ (H-5.5) \left(.5(H-5.5)\right)^{3/2}}$

2. $Q_B = C_B L_B \ H_B^{3/2}$

$C_B = 3.3$

$L_B = 20'$

$H_B = H$

$\underline{Q_B = 3.3 \ (20) \ H^{3/2}}$

3. $Q_C = C_C L_C \ H_C^{3/2}$

$C_C = 3.0$

$L_C = 37'$

$H_C = H - 1.0$

$Q_C = 3.0 \ (37) \ (H-1.0)^{3/2}$

4. $Q_D = C_D L_D \ H_D^{3/2}$

$C_D = 3.3$

$L_D = 45'$

$H_D = H - 4.5$

$Q_D = 3.3 \ (45) \ (H-4.5)^{3/2}$

5. $Q_E = C_E L_E H_E$

$C_E = 3.0$

$L_E = 60'$

$H_E = H - 5.5$

$Q_E = 3.0(60)(H-5.5)^{3/2}$

6. $Q_F = Q_A = 2.8(H-5.5)(.5(H-5.5))^{3/2}$

$Q_{TOT} = Q_A + Q_B + Q_C + Q_D + Q_E + Q_F$

```
LIST
100 REM STAGE DISCHARGE CALC FOR TODD LAKE DAM JOB 148
110 REM QA=Q3, QB=Q1, QC=Q2, QD=Q4, QE=Q5, QF=Q6, TOTAL=Q9
120 PAGE
130 C1=3
140 C2=2.8
150 C3=3.3
160 E=1.5
170 PRINT "TOTAL DISCHARGE FROM TODD LAKE AS FUNC OF HEAD"
180 PRINT USING 190:
190 IMAGE // 2T"HEAD"30T"DISCHARGE"
200 PRINT USING 210:
210 IMAGE 10T"TOTAL       QA       QB       QC       QD       QE       QF"
220 FOR H=0 TO 20 STEP 0.5
230 Q1=C3*20*H↑E
240 Q2=0
250 IF H<=1 THEN 270
260 Q2=C1*37*(H-1)↑E
270 Q3=0
280 Q4=0
290 Q5=0
300 Q6=0
310 IF H<=4.5 THEN 370
320 Q4=C3*45*(H-4.5)↑E
330 IF H<=5.5 THEN 370
340 Q5=C1*60*(H-5.5)↑E
350 Q6=C2*(H-5.5)*(0.5*(H-5.5))↑E
360 Q3=C2*(H-5.5)*(0.5*(H-5.5))↑E
370 Q9=Q1+Q2+Q3+Q4+Q5+Q6
380 PRINT USING 390:H,Q9,Q3,Q1,Q2,Q4,Q5,Q6
390 IMAGE 1T,2D.1D,9D,9D,8D,8D,8D,8D,8D
400 NEXT H
410 END
```

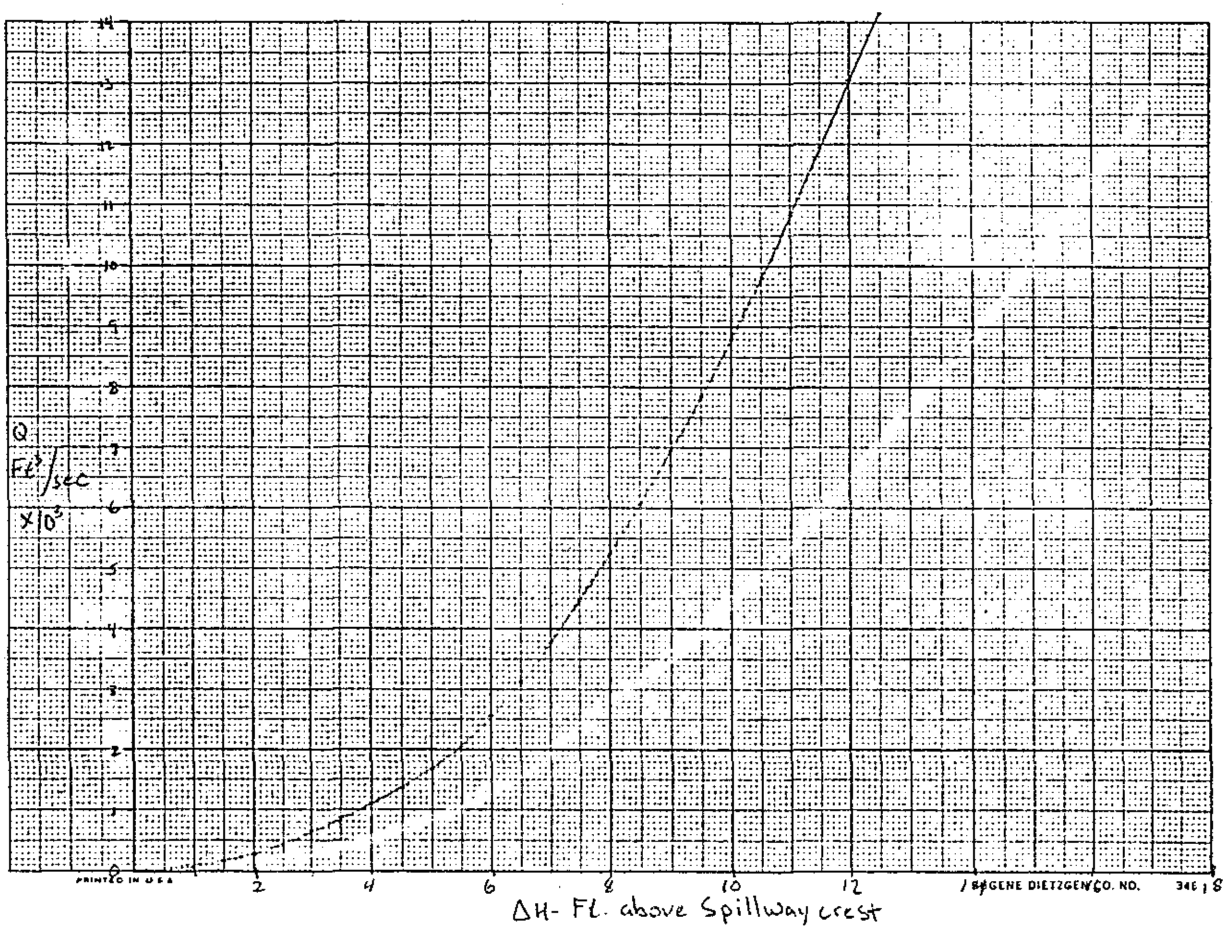
TOTAL DISCHARGE FROM TODD LAKE AS FUNC OF HEAD

HEAD			DISCHARGE				
	TOTAL	QA	QB	QC	QD	QE	QF
0.0	0	0	0	0	0	0	0
0.5	23	0	23	0	0	0	0
1.0	66	0	66	0	0	0	0
1.5	160	0	121	39	0	0	0
2.0	298	0	187	111	0	0	0
2.5	465	0	261	204	0	0	0
3.0	657	0	343	314	0	0	0
3.5	871	0	432	439	0	0	0
4.0	1105	0	528	577	0	0	0
4.5	1357	0	630	727	0	0	0
5.0	1678	0	738	888	53	0	0
5.5	2059	0	851	1060	149	0	0
6.0	2548	0	970	1241	273	64	0
6.5	3127	1	1094	1432	420	180	1
7.0	3777	3	1222	1631	587	331	3
7.5	4487	6	1356	1839	772	509	6
8.0	5253	10	1493	2056	972	712	10
8.5	6070	15	1636	2280	1188	935	15
9.0	6935	23	1782	2512	1418	1179	23
9.5	7847	32	1933	2751	1660	1440	32
10.0	8803	43	2087	2997	1915	1718	43
10.5	9801	55	2246	3250	2182	2012	55
11.0	10841	70	2408	3510	2461	2322	70
11.5	11921	87	2574	3777	2750	2645	87
12.0	13039	107	2744	4050	3050	2983	107
12.5	14196	128	2917	4329	3360	3334	128
13.0	15390	152	3094	4614	3680	3697	152
13.5	16620	179	3274	4906	4009	4073	179
14.0	17886	209	3457	5203	4348	4461	209
14.5	19187	241	3644	5506	4696	4860	241

15.0	20523	275	3834	5815	5053	5271	275
15.5	21892	313	4028	6129	5418	5692	313
16.0	23295	354	4224	6449	5791	6124	354
16.5	24732	397	4424	6774	6173	6567	397
17.0	26201	444	4626	7104	6563	7020	444
17.5	27702	494	4832	7440	6961	7482	494
18.0	29235	547	5040	7780	7366	7955	547
18.5	30800	603	5252	8126	7779	8437	603
19.0	32396	663	5466	8477	8199	8928	663
19.5	34024	726	5683	8832	8627	9429	726
20.0	35682	793	5903	9193	9062	9939	793

TODD LAKE #5

DISCHARGE - STAGE CURVE



STORAGE - STAGE RELATIONSHIP

Surface area of lake from existing data is 168 acres

ASSUME NO SPREADING AS THE WATER RISES;

For each foot of rise, ΔStorage = ΔS = 168 Acre ft : (H)(A)

= 168(43,560) = 7,318,080 ft^3

WITH A DRAINAGE AREA OF 18.5 mi^2

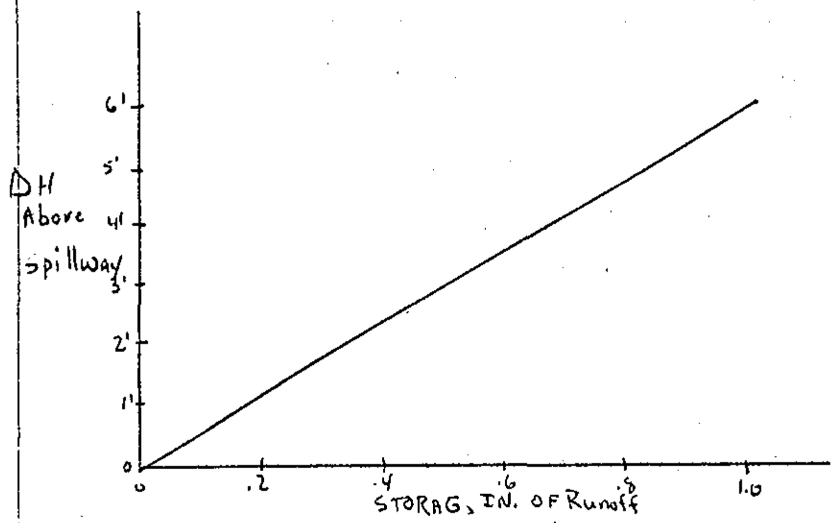
1" of runoff would cause:

$$\frac{18.5 \text{ in mi}^2}{168 \text{ acre} \left(.0015625 \frac{\text{mi}^2}{\text{acre}}\right)} = 70.48'' \text{ rise in water surface}$$

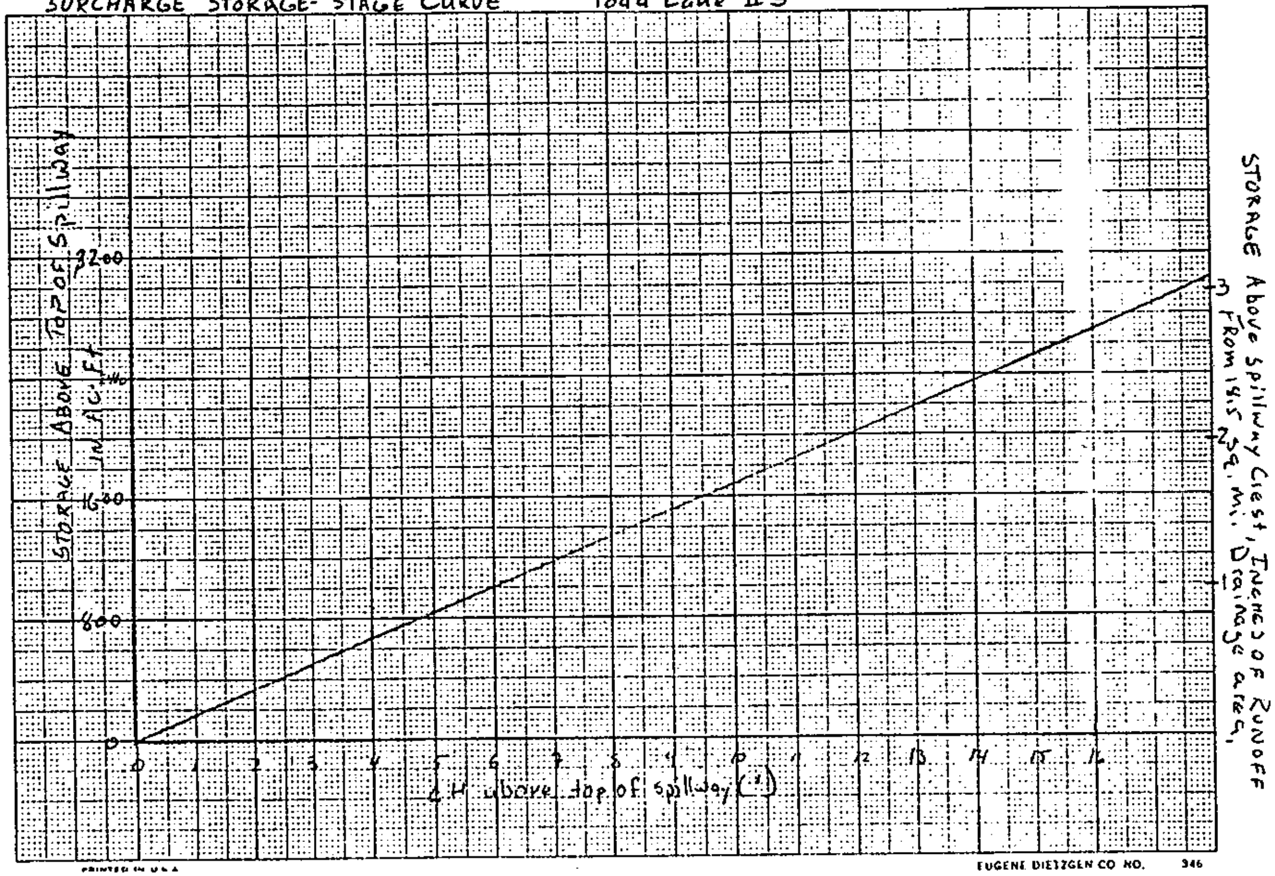
1 foot of rise = .170" runoff

2 feet " " = .341" "

3 " " " = .511" " , etc.

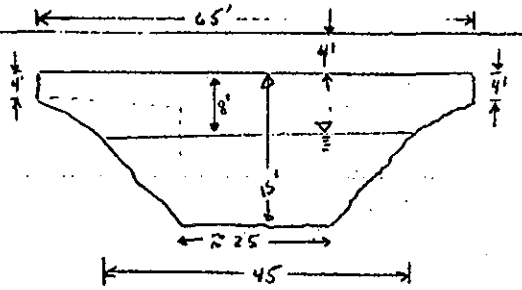


SURCHARGE STORAGE- STAGE CURVE Todd Lake #5



SOME CONSIDERATION MUST BE GIVEN TO WHETHER OR NOT THE NEW RTE 103 HIGHWAY EMBANKMENT WHICH FOLLOWS THE ALLIGNMENT OF THE OLD RAILROAD WILL SERVE AS A DAM AND THUS REDUCE THE PEAK FLOW THAT REACHES THE TODD LAKE DAM. A CROSS SECTION AT THE HIGHWAY BRIDGE WAS TAKEN ON 7/12/78.

NOT TO SCALE



GIVEN THE LARGE OPENNING ≈ 750 FT²
AND THE LIMITED FREEBOARD ONCE THE BRIDGE GOES TO PRESSURE FLOW, IT IS UNLIKELY THAT A SIGNIFICANT REDUCTION IN FLOW WOULD RESULT FROM THE BRIDGE.

A SECOND CONCERN IS WHETHER THE STORAGE IN THE LAKE FOR A 11.8' SURCHARGE EXCEEDS THE TOTAL PROBABLE MAXIMUM RUNOFF.

19" PROB. MAX. RUNOFF FROM 18.5 mi^2

YIELDS $\dfrac{\frac{19}{12} \times 18.5 \times 5280^2}{43560} = 18747$ AF

STORAGE AT $H = 11.8$ FT IS $\doteq 2000$ AF

THUS THE RISE WATER SURFACE IS FEASIBLE.

ESTIMATED DOWNSTREAM DAM FAILURE FLOOD STAGES
Based on LOE "Rule of Thumb" Guidance April, 1978

STEP 1: RESERVOIR STORAGE AT TIME OF FAILURE

ASSUME: FAILURE WHEN STAGE IS 3.5 foot over side weirs, 8.0 ft, over normal spillway elevation, 7.0 ft over the top of the dam. THIS IS ≈ A 100 YEAR FLOW LEVEL WHERE Q ≈ 5000 cfs
S = Normal storage + Surcharge.

Normal storage at the top of the dam (1' above spillway crest) is 1513 ac-ft.
surcharge is 1200 ac-ft.

S = 1513 + 1200 = 2713 Ac-Ft

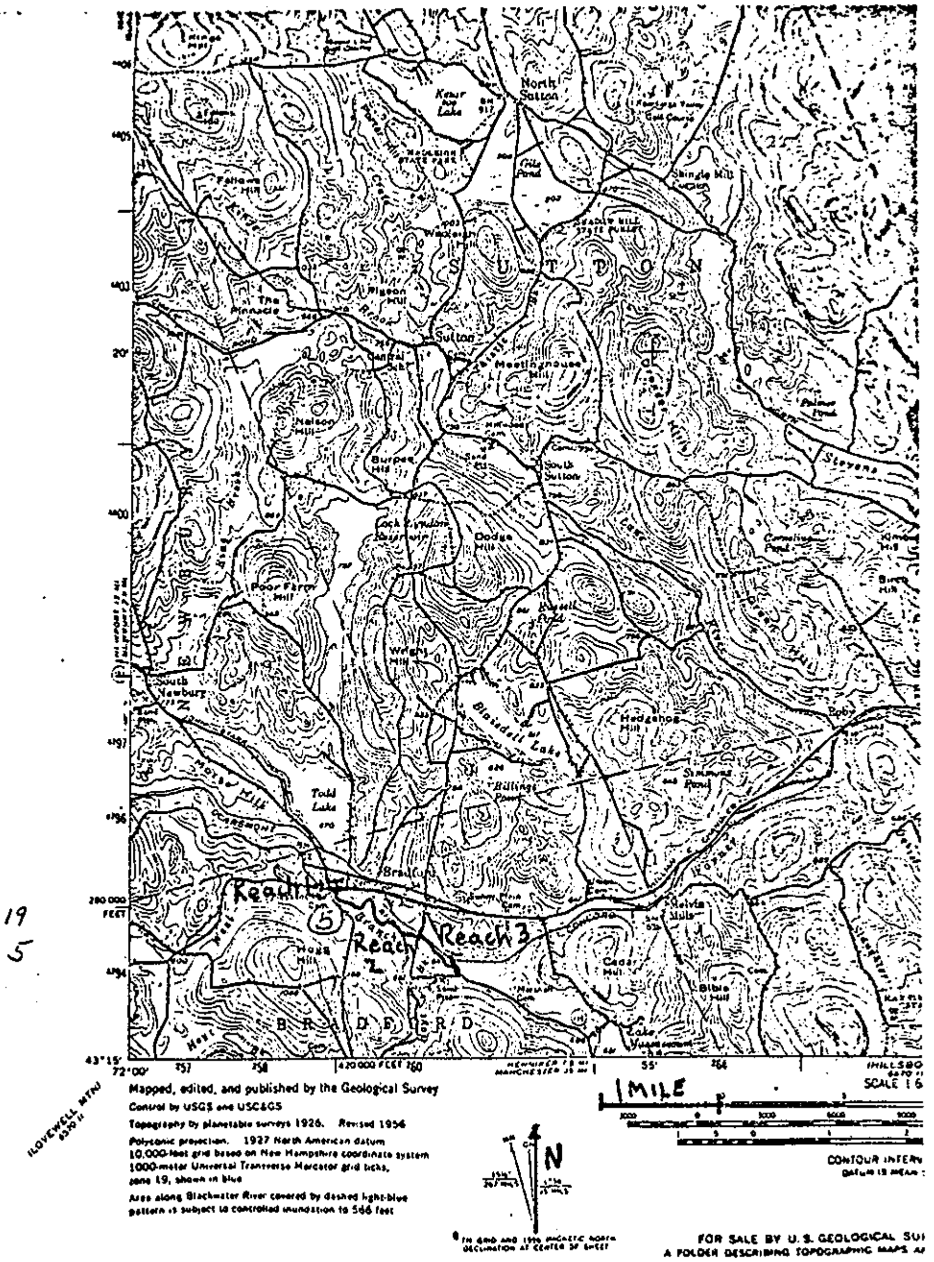
STEP 2: PEAK FAILURE OUTFLOW (Q_{P_1})

$$Q_{P_1} = 8/27\ W_b \sqrt{g}\ Y_o^{3/2}$$

W_b = 40% of width = .4(102) ≈ 40.8'
g = 32.2
Y_o = 12.0' + 7' = 19.0'

$$Q_{P_1} = \frac{8}{27}(40.8)\sqrt{32.2}\ 19^{3/2}$$
$$= 5680 \text{ cfs}$$

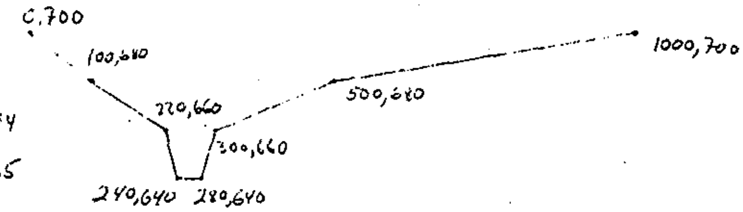
19
5


North Sutton
Kezar Lake
Sutton
South Sutton
S U T T O N
Meetinghouse Hill
Nelson Hill
Burpee Hill
Dodge Hill
Poor Farm Hill
Wright Hill
South Newbury
Blaisdell Lake
Hedgehog Hill
Todd Lake
Billings Pond
Hogg Hill
Cedar Hill
Bible Hill
Lake Massasecum
B R A D F O R D
Reach 1
Reach 2
Reach 3
5
1 MILE
N
Mapped, edited, and published by the Geological Survey
Control by USGS and USC&GS
Topography by planetable surveys 1926. Revised 1956
Polyconic projection. 1927 North American datum
10,000-foot grid based on New Hampshire coordinate system
1000-meter Universal Transverse Mercator grid ticks,
zone 19, shown in blue
Area along Blackwater River covered by dashed light-blue
pattern is subject to controlled inundation to 566 feet
FOR SALE BY U. S. GEOLOGICAL SU
A FOLDER DESCRIBING TOPOGRAPHIC MAPS A
CONTOUR INTERV

Step 3: Assumed X-sections for reaches shown on the U.S.G.S. Topo Map:

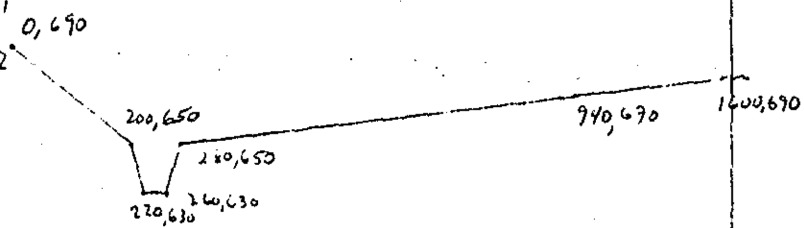
Reach 1 - Below dam to 103 Bridge.

L=200'
S=.0074
n=.035



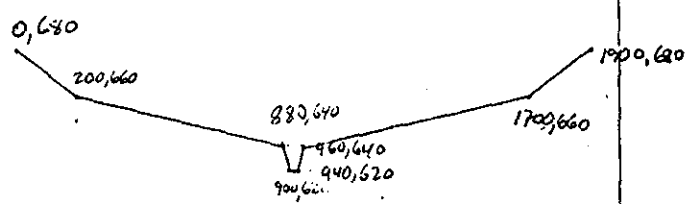
Reach 2 - 103 Bridge 114 Bridge

L=6000'
S=.0042
n=.035



Reach 3 114 Bridge to 114 Bridge #2

L=2700'
S=.001
n=.035



DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	640.0	0.0	0.0	0.0	0.0	0.0
1.0	641.0	41.0	42.8	1.0	39.8	145.8
2.0	642.0	84.0	45.7	1.8	126.1	462.0
3.0	643.0	129.0	48.5	2.7	247.8	907.4
4.0	644.0	176.0	51.3	3.4	400.4	1466.5
5.0	645.0	225.0	54.1	4.2	581.9	2130.9
6.0	646.0	276.0	57.0	4.8	790.6	2895.4
7.0	647.0	329.0	59.8	5.5	1025.9	3757.0
8.0	648.0	384.0	62.6	6.1	1287.2	4713.8
9.0	649.0	441.0	65.5	6.7	1574.1	5764.7
10.0	650.0	500.0	68.3	7.3	1886.6	6909.2
11.0	651.0	561.0	71.1	7.9	2224.7	8147.2
12.0	652.0	624.0	73.9	8.4	2588.4	9478.9
13.0	653.0	689.0	76.8	9.0	2977.8	10905.8
14.0	654.0	756.0	79.6	9.5	3393.1	12425.9
15.0	655.0	825.0	82.4	10.0	3834.5	14042.6
16.0	656.0	896.0	85.3	10.5	4302.4	15755.9
17.0	657.0	969.0	88.1	11.0	4796.9	17566.8
18.0	658.0	1044.0	90.9	11.5	5318.3	19476.4
19.0	659.0	1121.0	93.7	12.0	5867.0	21485.8
20.0	660.0	1200.0	96.6	12.4	6443.3	23596.3
21.0	661.0	1288.0	112.7	11.4	6540.2	23951.2
22.0	662.0	1392.0	128.8	10.8	6808.6	24933.9
23.0	663.0	1512.0	145.0	10.4	7223.5	26453.4
24.0	664.0	1648.0	161.1	10.2	7772.1	28462.3
25.0	665.0	1800.0	177.2	10.2	8448.2	30938.3
26.0	666.0	1968.0	193.4	10.2	9249.7	33873.6
27.0	667.0	2152.0	209.5	10.3	10177.1	37269.8
28.0	668.0	2352.0	225.6	10.4	11232.4	41134.4
29.0	669.0	2568.0	241.8	10.6	12418.7	45478.8

TODD LAKE DAM - REACH 1

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	630.0	0.0	0.0	0.0	0.0	0.0
1.0	631.0	41.0	42.8	1.0	39.8	109.9
2.0	632.0	84.0	45.7	1.8	126.1	348.0
3.0	633.0	129.0	48.5	2.7	247.8	683.6
4.0	634.0	176.0	51.3	3.4	400.4	1104.8
5.0	635.0	225.0	54.1	4.2	581.9	1605.3
6.0	636.0	276.0	57.0	4.8	790.6	2181.3
7.0	637.0	329.0	59.8	5.5	1025.9	2830.4
8.0	638.0	384.0	62.6	6.1	1287.2	3551.2
9.0	639.0	441.0	65.5	6.7	1574.1	4342.9
10.0	640.0	500.0	68.3	7.3	1886.6	5205.2
11.0	641.0	561.0	71.1	7.9	2224.7	6137.8
12.0	642.0	624.0	73.9	8.4	2588.4	7141.2
13.0	643.0	689.0	76.8	9.0	2977.8	8215.5
14.0	644.0	756.0	79.6	9.5	3393.1	9361.3
15.0	645.0	825.0	82.4	10.0	3834.5	10579.3
16.0	646.0	896.0	85.3	10.5	4302.4	11870.0
17.0	647.0	969.0	88.1	11.0	4796.9	13234.3
18.0	648.0	1044.0	90.9	11.5	5318.3	14672.9
19.0	649.0	1121.0	93.7	12.0	5867.0	16186.8
20.0	650.0	1200.0	96.6	12.4	6443.3	17776.8
21.0	651.0	1299.0	134.7	9.6	5890.3	16250.9
22.0	652.0	1436.0	172.8	8.3	5895.8	16266.1
23.0	653.0	1611.0	210.9	7.6	6252.5	17250.3
24.0	654.0	1824.0	249.0	7.3	6883.9	18992.3
25.0	655.0	2075.0	287.1	7.2	7761.1	21412.3
26.0	656.0	2364.0	325.3	7.3	8876.0	24488.4
27.0	657.0	2691.0	363.4	7.4	10230.9	28226.6
28.0	658.0	3056.0	401.5	7.6	11833.3	32647.4
29.0	659.0	3459.0	439.6	7.9	13693.5	37779.5

TODD LAKE DAM - REACH 2

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	620.0	0.0	0.0	0.0	0.0	0.0
1.0	621.0	41.0	42.8	1.0	39.8	53.6
2.0	622.0	84.0	45.7	1.8	126.1	169.8
3.0	623.0	129.0	48.5	2.7	247.8	333.6
4.0	624.0	176.0	51.3	3.4	400.4	539.1
5.0	625.0	225.0	54.1	4.2	581.9	783.3
6.0	626.0	276.0	57.0	4.8	790.6	1064.4
7.0	627.0	329.0	59.8	5.5	1025.9	1381.1
8.0	628.0	384.0	62.6	6.1	1287.2	1732.8
9.0	629.0	441.0	65.5	6.7	1574.1	2119.1
10.0	630.0	500.0	68.3	7.3	1886.6	2539.9
11.0	631.0	561.0	71.1	7.9	2224.7	2995.0
12.0	632.0	624.0	73.9	8.4	2588.4	3484.5
13.0	633.0	689.0	76.8	9.0	2977.8	4008.7
14.0	634.0	756.0	79.6	9.5	3393.1	4567.9
15.0	635.0	825.0	82.4	10.0	3834.5	5162.2
16.0	636.0	896.0	85.3	10.5	4302.4	5792.0
17.0	637.0	969.0	88.1	11.0	4796.9	6457.7
18.0	638.0	1044.0	90.9	11.5	5318.3	7159.7
19.0	639.0	1121.0	93.7	12.0	5867.0	7898.4
20.0	640.0	1200.0	96.6	12.4	6443.3	8674.2
21.0	641.0	1315.5	167.6	7.8	5199.2	6999.3
22.0	642.0	1502.0	238.6	6.3	5123.6	6897.5
23.0	643.0	1759.5	309.7	5.7	5606.0	7546.9
24.0	644.0	2088.0	380.7	5.5	6497.6	8747.3
25.0	645.0	2487.5	451.7	5.5	7761.5	10448.7
26.0	646.0	2958.0	522.7	5.7	9398.5	12652.5
27.0	647.0	3499.5	593.8	5.9	11425.0	15380.7
28.0	648.0	4112.0	664.8	6.2	13864.2	18664.3
29.0	649.0	4795.5	735.8	6.5	16742.2	22538.8

TODD LAKE DAM - REACH 3

STEP 4: REACH 1:

$Q_{P1} = 5680$ cfs

$H = 8.9$ FT   AREA = 430 FT^2

$V_1 = L * AREA = 200' * 430' = 86000 \text{ FT}^2 / 43560 = 1.97$ AF

OBVIOUSLY THERE WOULD BE NO ATTENUATION WHEN COMPARED TO S = 2713 AF

REACH 2:

$Q_{P1} = 5680$ cfs

$H = 10.5$ AREA ≈ 530 FT^2

$V_1 = L * AREA: 6000' \times 530' = 3.18 \times 10^6 \text{ FT}^3$

$\frac{3.18 \times 10^6}{43560} = 73.0$ AF $\doteq \frac{1}{2}$ S

$Q_{P2T}: Q_{P1}\left(1 - \frac{V_1}{S}\right) = 5680\left(1 - \frac{73.0}{2713}\right) = 5527$

$H = 10.3$ AREA = 515'

$V_1 = 6000 \times 515 = 3.09 \times 10^6 \text{ FT}^3 \quad \frac{3.09 \times 10^6}{43560} = 70.9$ AF

$V_{AVG} = 72$

$Q_{P2} = Q_{P1}\left(1 - \frac{V_{AVG}}{S}\right) = 5680\left(1 - \frac{72}{2713}\right) = 5529.$

REACH 3: $Q_{P1} = 5529.$

$H = 15.6$ AREA = 868 FT^2

$V_1 = L * AREA = 2700 * 868 = 2.34 \times 10^6 \quad 2.34 \times 10^6 / 43560 = 53.8$ AF

$Q_{P2T} = Q_{P1}\left(1 - \frac{V_1}{S}\right) = 5529\left(1 - \frac{53.8}{2713}\right) = 5419$

$H = 15.5$ AREA = 860

$V_1 = 2700 * 860 / 43560 = 53.3$ AF $V_{AVG} = 53.5$

$Q_{P3} = 5529\left(1 - \frac{53.5}{2713}\right) \approx 5420.$

$H \approx 15.5'$

DAMS 148 | TODD LAKE | 7-14-78 DWW

DISCUSSION ON DAM BREAK - DOWNSTREAM FLOOD HAZARDS.

WITH THE EXCEPTION OF THE THREE BUILDINGS IMMEDIATELY DOWNSTREAM OF TODD LAKE DAM THERE IS NO SIGNIFICANT MAN MADE DEVELOPMENT IN THE FLOOD PLAIN DOWNSTREAM OF THE DAM FOR AT LEAST 3 MILES.

THE FLOOD HAZARD FOR THE ASSUMED DAM BREAK CONDITION WOULD BE LESS THAN THE HAZARD RESULTING FROM THE LARGER SDF.

THE WOODEN COVERED BRIDGE AT THE SECOND ROAD CROSSING WOULD PROBABLY BE SEVERELY DAMAGED IF THE DAM BROKE.

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS